HIGHLY POWER SENSITIVE AND FIELD SENSITIVE MO DISK FOR 8 MB/s DATA TRANSFER

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Abstract- To realize 8 MB/s data transfer rate at 45 m/s linear velocity, three key items such as increasing power sensitivity, increasing field sensitivity and pit-edge recording are investigated. To increase power sensitivity, the film thicknesses of the magnetic layer and protective layers are optimized. To decrease the switching field, a magnetic capping layer with in-plane magnetization is inserted in the structure. Moreover, through observation of domain shapes and jitter measurements, it is found that high linear velocity recording is advantageous for pit-edge recording.

KEYWORDS: POWER SENSITIVITY, FIELD SENSITIVITY, PIT-EDGE, LINEAR VELOCITY, MAGNETIC CAPPING LAYER, MO DISK

INTRODUCTION

First generation Magneto-Optical 5.25 inch disks with about a 1MB/s data transfer rate are already been commercially available. To extend their application area, it is very important to increase the data transfer rate [1]. This paper reports 8 MB/s capability through the application of pit-edge recording at speed 45 m/s using a 10 inch diameter disk fabricated by means of first generation MO process. Such a high performance disk requires three key techniques. First, power sensitivity must be increased to match commercially available laser of 30 to 40 mW output. Second, the thermal design of disk layer structure must be suitable for precise domain edge control. Third, a magnetic layer should be designed so as to decrease the external magnetic field for switching, to accommodate the reduce size bias coil even to the extent of eliminating the external bias magnets in a two beam over-writing scheme.

EXPERIMENT

Four kinds (A, B, C and C') of MO disk of quadri or fivefold layer structure, as shown in Fig.1, were prepared by rf or dc magnetron sputtering on a photo-polymerized glass disk with 10 inch diameter. Each consisted of a TbFeCo film with/without magnetic capping layer, nitride layers sandwiching the film and an over-coated Al-alloy reflection layer. The main parameters of the disks were decided upon as set out in

Fig.1 Disk layer structure.

Table.1 Each layer thickness and magnetic characteristics.

	disk A	disk B	disk C	disk C'
TbFeCo	35nm	20nm		
Al Alloy	70nm	50nm		
Magnetic Capping Layer	—	2nm		—
Curie Temperature	220°C		190°C	
Compensation Temperature	<100°C		130°C	

Table.1. The temperature dependence of the coercivity and the Kerr rotation angle were measured by polar Kerr hysteresis loops. Both recording laser power dependence and external field dependence of Carrier to Noise ratio (CNR) were measured for $0.6 \mu\text{m}$ bit length recording by using a 780 nm wavelength laser and lens of numerical aperture 0.55. The recorded domains were observed using a TV camera mounted on a polarized microscope.

RESULTS AND DISCUSSION

Power sensitivity

Two approaches are available to increase power sensitivity. One is to decrease the thickness of films and adapt an air sandwich structure to reduce thermal diffusion from the top surface. The other is to reduce the Curie temperature of the magnetic layer, to lower the recording temperature. We adopted both approaches. Fig.2 shows the coercivity and Kerr rotation angle of disks A, B and C as a function of temperature. A substantial reduction of the recording laser power was observed for disk B. This was compared

Fig.2 Temperature dependence of coercivity and Kerr rotation angle.

with disk A which possessed parameters typical of conventional disks. Disk C was observed to display slightly increased power sensitivity over disk B. Fig.3 shows CNR as a function of recording laser power for linear velocities of 7.5 m/s ,

Fig.3 Carrier to Noise ratio as a function of recording laser power for each linear velocity.

Fig.4 Suitable laser power for $0.6 \mu\text{m}$ bit length recording up to 45 m/s linear velocity.

15 m/s, 22.5 m/s and 45 m/s. Fig.4 shows recording laser power which gives maximal CNR (CNR Peak Power) as a function of linear velocity for disks A, B and C. In disk A, the most suitable laser power for 0.6 μm bit length recording is 10 mW on the disk surface at 22 m/s, and may exceed 20 mW at 45 m/s. While, in disk C, it is only 8 mW at 45 m/s. Fig.5 shows the recording frequency dependence of CNR in disk C. Even at the highest recording frequency of 32 MHz, re-

Fig.5 Recording frequency dependence of CNR for 0.6 μm bit length recording.

quired for realizing pit-edge recording of the 8 MB/s data transfer rate in a 10 inch diameter MO disk system, CNR is 46 dB, which is sufficient for digital data recording.

Domain edge control

The thickness of each layer for disks B and C were decided upon to optimize for pit-edge recording through computer simulations of recorded domain shape. In disk C, the compensation temperature was kept a little higher (about 130

Photo.1 Recording domain images observed by a polarized microscope.

°C) to restrict expansion in the recorded domains [2]. Photo.1(a) shows the domain patterns in disk A (conventional disk) written at a linear velocity of 7.5 m/s, and photo.1(b) shows those in disk C written at 22.5 m/s. Tear drop like domains can be seen in (a), while the domains are almost symmetrical in (b). This can be attributed to the fact that heat diffusion during irradiation of write spot is easier in the former than in the latter, because, in the latter case, the layers are thinner and the irradiation duration is much shorter than in the former. This results in the formation of tear drop like isothermal lines in the former, but more symmetrical isothermal lines in the latter. In the case of pit-edge recording, asymmetry of the domain shape causes pit-edge jitter to be larger than in pit-position recording. A higher linear velocity condition, therefore, is more advantageous for pit-edge recording than a lower linear velocity condition.

Field sensitivity

Fig.6 shows Carrier (C) and Noise (N) levels as a function of the external field. In a conventional type quadri layer structure disk (C'), C level is saturated and N level is minimized at a field of 400 Oe (recording direction), and at minus 600 Oe (erasing direction), domains are not recorded. In such a case, a large magnetic coil or magnet is required for complete writing or erasing. For the reduction of switching field, it is essential to make the medium field sensitivity higher. A magnetic capping layer with in-plane magnetization exchange coupled with TbFeCo greatly reduces the switching field. As shown in Fig.6, in disk C with a magnetic capping layer, at only 100 Oe, the C level is saturated and N level is minimized, and at minus 100 Oe domains

Fig.6 Carrier C and Noise N of the disk without magnetic capping layer (Δ)(disk C') and with magnetic capping layer (O)(disk C) versus external field.

are not recorded. This can be explained as follows. In a disk with magnetic capping layer, complex domain nucleation is suppressed by an exchange coupled in-plane magnetization to make written mark consist of a single domain in a small external field region. In disks without magnetic capping layer, there remain microdomains up to a considerably high minus field, e.g. minus 300 Oe [3]. This enables one to design a simple drive in which a two beam overwrite scheme is realized by utilizing a leakage magnetic field from a lens actuator as an external field for switching. The strength of leakage field is about 200 Oe which is sufficient to write or erase domains.

CONCLUSION

Three key items to achieve a 8 MB/s data transfer rate 10 inch diameter MO disk are presented with the object to help expand MO application to high speed data transfer and digital image file systems. To increase power sensitivity, the thicknesses of TbFeCo and Al-alloy layers are decreased to 20 nm and 50 nm respectively and the Curie temperature lowered to 190 °C. Through domain shape observation and thermal simulation, it was found that high linear velocity recording is advantageous for pit-edge recording. To increase field sensitivity, a magnetic capping layer with in-plane magnetization is over-coated to exchange couple with TbFeCo. The compensation point of TbFeCo is fixed at 130 °C. The three items taken together will help realize the 8 MB/s data transfer rate.

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